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Title: ORBITING COMBUSTION NOZZLE ENGINE §

Applicant: R-JET ENGINEERING LTD. §

Attorney Docket: 1133/4 §

RESPONSE

Commissioner of Patents and Trademarks
BOX PCT
Washington, DC 20231

Dear Sir:

This is in response to the International Search Report sent March 31, 2004, a response to which is being made within two months.

We enclose herein amended claims. Please replace pages 39-42 with the enclosed replacement pages 39-42 (4 sheets).

REMARKS

Replacement claim 1 is claim 1 as filed, including limitations related to the limitations of claim 5 as filed, as described below. Replacement claim 3 is new. Replacement claim 4 re-introduces the remaining limitation of claim 5 as filed that is not recited in replacement claim 1. Replacement claims 13 and 14 are claims 14 and 15 as filed, amended as described below. Replacement claims 2, 5-12, 15-17 and 19 are claims 2, 6-13, 16-18 and 4 as filed. Replacement claims 18 and 20-23 are new.

The Examiner has cited Karlby et al., US Patent No. 2,784,551 (henceforth, "Karlby" as rendering claims 1 and 5 unpatentable. Karlby teaches a vertical flow gas turbine with multiple flame holders protruding into the combustion chamber (*e.g.*, flame holders **71** protruding into combustion chamber **61**). The flame holder of the present invention differs from Karlby's flame holders in at least three respects:

1. The flame holder of the present invention is annular. (This limitation also was recited in claim 5 as filed.)

2. The flame holder of the present invention encircles the inner casing.

3. The engine of the present invention has only one flame holder.

Therefore, claim 1 has been amended to recite the first and second innovative features of the flame holder of the present invention. New claim 3 recites the third innovative feature of the flame holder of the present invention.

These amendments are supported in the specification by flame holder **84**, as illustrated in Figure 4 and described on page 14 lines 13-26. Note in particular lines 20-21:

> Annular flame holder **84** is substantially a tubular structure attached to inner casing **60** by a plurality of struts **86**.

Note also that the OCN engine of figure 4 includes only one annular flame holder **84**.

The Examiner has cited Egnell et al., US Patent No. 4,345,426 (henceforth, "Egnell"), Stettler et al., US Patent No. 3,969, 892 (henceforth, "Stettler") and Buchheim, US Patent No. 4,192,139 (henceforth, "Buchheim") as rendering claim 14 unpatentable.

The prior art references that are closest to the present invention are Egnell and Buchheim. In Egnell, exhaust gases are recirculated to paths **14** and mixed with preheated air from passages **8** in paths **14** and then with fuel from fuel injection nozzle

17. In Buchheim, tubes **18** direct exhaust gases from flame tube **2** to nozzle section **9**, where the exhaust gases mix with air from air intake **7** and fuel from fuel injection nozzle **8**. In both cases, the exhaust gases apparently are propelled by a static pressure gradient, unlike Stettler, in which a jet pump (*e.g.*, jet pump **24**) is used to draw exhaust into incoming air.

The primary difference between the present invention and the prior art cited by the Examiner against claim 14 lies in the mechanism by which the static pressure gradient is created. According to the present invention, the static pressure gradient is created by an airflow vortex. Claim 14 now has been amended (as replacement claim 13) to recite this difference. Support for this amendment is found in the specification *inter alia* on page 16 lines 10-11:

> In an OCN engine, the airflow vortex generates a radial static pressure gradient inside the combustion chamber that increases towards the outer casing.

The Examiner has cited Matsumoto et al., US Patent No. 5,695,319 (henceforth, "Matsumoto") as rendering claim 15 unpatentable. Matsumoto teaches a gas turbine in which a cooling fluid passes via an axial channel (*e.g.*, the channel that feeds vapor passages **86** and **87** in figure 4), that rotates along with turbine wheels, to the interiors of the bases of the blades of the turbine wheels (*e.g.*, turbine blades **51** ands **52** in Figure 4).

There are two principal differences between the present invention and the teachings of Matsumoto. First, the axial channel of the present invention is annular. Second, the axial channel of the present invention directs the cooling fluid at the outer surfaces of the blade bases. Claim 15 now has been amended (as replacement claim 14) to recite these differences. Support for these amendments is found in the specification in Figures 4 and 6 and the accompanying text. The annular axial channel

is the channel defined by flame holder **84** and inner casing **60**. At the aft portion of this annular axial channel are cooling nozzles **104** that are described as follows on page 20 lines 8-9:

> In Figures 3 and 4, cool air emerges from each blade cooling nozzle **104** directly at the base of a corresponding nozzle wheel blade **98**, as depicted in Figures 6A and 6B.

The Examiner cited no prior art against claim 3. Therefore, new claims 18 and 19 have been added. Claim 18 is claim 3 as filed, rewritten in independent form. Claim 19 is claim 4 as filed, rewritten to depend from claim 17.

Finally, new claims 20-23 have been added.

New claim 20 is claim 1 as filed, without the characterizing portion, and including the limitation that the compressor-driving nozzle wheel includes a plurality of blades that define between them a corresponding plurality of convergent-divergent nozzles. Support for this limitation is found in the specification in Figure 6A as described on page 18 lines 27-31:

> Compressor-driving nozzle wheel **50** is substantially a plurality of nozzle wheel blades **98** radiating outwards from a hub attached to rotating shaft **52**. Figure 6A is an axial cross section of a compressor-driving nozzle wheel **50** depicting three blades **98** and two nozzles **102**. As is seen in Figure 6A, the space between two adjacent nozzle wheel blades **98** defines a nozzle **102**. Nozzle **102** preferably has a converging-diverging shape.

New claim 21 is claim 1 as filed, without the characterizing portion, and including the limitation that the engine includes a free nozzle wheel aft of the compressor-driving nozzle wheel but lacks stator guide vanes between the nozzle wheels. Support for this limitation is found in the specification on page 21 lines 21-22:

> No stationary guide vanes are required between the two nozzle wheels.

as well as in Figure 7, in which there are no stator guide vanes intervening between compressor-driving nozzle wheel **50** and free nozzle wheel **108**.

New claim 22 adds to claim 21 the limitations that the free nozzle wheel includes a plurality of blades that define between them a corresponding plurality of nozzles, and that the blades are positioned so that gas jets emerge from the nozzles at an angle of at least about 82 degrees from parallel with the rotational axis of the rotating assembly. Support for this limitation is found in the specification in page 21 lines 24-27:

> The greater efficiency is due to the fact that for reasons analogous to those discussed for the compressor driving nozzle wheel of an OCN engine, the nozzle angles of a free nozzle wheel are significantly greater than those of the analogous free turbine blades.

combined with page 19 lines 10-11:

> In Figure 6A, nozzle wheel blades **98** are positioned so that the exit angle of gas jets exiting nozzles **102** is 82° from parallel with the engine axis...

New claim 23 is claim 1 as filed, without the characterizing portion, and including the limitation that either the primary compressor or the compressor-driving nozzle wheel (or both) is partly blocked. Support for this limitation is found in the specification in Figure 8 as described on page 22 lines 16-21.

Respectfully submitted,

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Date: May 31, 2004

WHAT IS CLAIMED IS:

1. An engine, comprising:

a. a rotating assembly including a primary compressor, an inner casing and a compressor-driving nozzle wheel;

b. an outer casing, enclosing said rotating assembly; and

c. a substantially annular flame holder encircling said inner casing within said combustion chamber;

so that at least one combustion chamber is defined in the space between said primary compressor, said inner casing, said compressor-driving nozzle wheel and said outer casing, characterized in that said outer casing does not rotate with said rotating assembly.

2. The engine of claim 1, wherein said at least one combustion chamber is substantially a single annular combustion chamber.

3. The engine of claim 1, wherein said rotating assembly includes a single said flame holder.

4. The engine of claim 1, wherein said flame holder is included in said rotating assembly.

5. The engine of claim 1, further comprising:

c. a substantially tubular element surrounding said inner casing, wherein a leading edge of said tubular element is positioned aft of said primary compressor so as to divide airflow from said primary compressor into an outer airflow and an inner airflow, wherein said outer airflow is between said tubular element and said outer casing and wherein said inner airflow is between said tubular element and said inner casing

6. The engine of claim 5 wherein through said substantially tubular element are perforations allowing communication between said inner airflow and said outer airflow.

7. The engine of claim 1 further comprising:

c. a rotating diffuser between said primary compressor and said combustion chamber.

8. The engine of claim 7 wherein said rotating diffuser includes extensions to terminal blades of said primary compressor.

9. The engine of claim 1 wherein said rotating assembly further includes at least one fuel injector.

10. An engine comprising:

a. a combustion chamber having an axis; and

b. a combustion chamber compressor, coaxial with and radially inwards from said combustion chamber configured to counteract axial backflow in said combustion chamber.

11. The engine of claim 10 wherein said combustion chamber compressor includes:

c. at least two combustion chamber compressor blades arrayed about said axis of said combustion chamber in at least one circle; and

d. a substantially tubular combustion chamber compressor body encasing said combustion chamber compressor blades.

12. The engine of claim 10 further comprising:

c. a rotating combustion chamber inner casing coaxial with said combustion chamber;

d. at least two combustion chamber compressor blades rigidly attached to said rotating combustion chamber inner casing and arrayed about said axis of said combustion chamber in at least one circle; and

e. a substantially tubular combustion chamber compressor body encasing said combustion chamber compressor blades.

13. In an engine having a combustion chamber wherein a mixture of fuel and air is burned, a method of reducing NO_x emissions comprising:

a. making a combustible mixture by combining exhaust, fuel and air in a first region of the engine;

b. establishing an airflow vortex, within the combustion chamber, that creates a higher static pressure in a second region of the engine than in said first region of the engine; and

c. burning said combustible mixture in the combustion chamber;
wherein said exhaust is taken from said second region of the engine by said higher static pressure in said second region.

14. A method of cooling a blade of a bladed rotating wheel attached to the terminal end of a rotating axis through a blade base, comprising:

a. providing at least one substantially annular axial channel rotating with the rotating axis, said at least one channel having an inlet and an outlet;
b. feeding a cooling fluid into said at least one channel through said inlet; and
c. directing cooling fluid emerging from said channel through said outlet at an outer surface of the blade base.

15. The method of claim 14 further comprising:

d. increasing the pressure of said cooling fluid emerging through said outlet using a pressure-increasing device positioned inside said at least one channel.

16. The method of claim 14 wherein said bladed rotating wheel is a nozzle wheel and wherein said blade is a nozzle wheel blade.

17. The method of claim 14 wherein said bladed rotating wheel is a turbine wheel and wherein said blade is a turbine blade.

18. An engine, comprising:

a. a rotating assembly including a primary compressor, an inner casing and a compressor-driving nozzle wheel;
b. an outer casing, enclosing said rotating assembly; and
c. a combustion chamber compressor in said combustion chamber;

so that at least one combustion chamber is defined in the space between said primary compressor, said inner casing, said compressor-driving nozzle wheel and said outer casing, characterized in that said outer casing does not rotate with said rotating assembly;

19. The engine of claim 18, wherein said combustion chamber compressor comprises a plurality of combustion chamber compressor blades attached to said inner casing.

20. An engine, comprising:

a. a rotating assembly including a primary compressor, an inner casing and a compressor-driving nozzle wheel; and

b. an outer casing, enclosing said rotating assembly;

so that at least one combustion chamber is defined in the space between said primary compressor, said inner casing, said compressor-driving nozzle wheel and said outer casing, said compressor-driving nozzle wheel including a plurality of blades that define between them a corresponding plurality of nozzles, each said nozzle having a convergent-divergent shape.

21. An engine, comprising:

a. a rotating assembly including a primary compressor, an inner casing and a compressor-driving nozzle wheel; and

b. an outer casing, enclosing said rotating assembly;

so that at least one combustion chamber is defined in the space between said primary compressor, said inner casing, said compressor-driving nozzle wheel and said outer casing, the engine further comprising:

c. a free nozzle wheel aft of said compressor-driving nozzle wheel;

and wherein the engine lacks stator guide vanes between said nozzle wheels.

22. The engine of claim 21, wherein said free nozzle wheel includes a plurality of blades that define between them a corresponding plurality of nozzles, said blades being positioned so that gas jets that emerge from said nozzles emerge at an angle of at least about 82 degrees from parallel with a rotational axis of said rotating assembly.

23. An engine, comprising:

a. a rotating assembly including a primary compressor, an inner casing and a compressor-driving nozzle wheel; and

b. an outer casing, enclosing said rotating assembly;

so that at least one combustion chamber is defined in the space between said primary compressor, said inner casing, said compressor-driven nozzle wheel and said outer casing, wherein at least one of said primary compressor and said nozzle wheel is partly blocked.